Temporal Dynamics of two Tropical Ant Species, *Iridomyrmex sanguineus* and *Oecophylla smaragdina*, in relation to Temperature and Humidity

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Abstract

The activity of the tropical meat ant *Iridomyrmex sanguineus*, in the Darwin region, is strongly affected by environmental temperature and relative humidity. Activity peaked at air temperatures 3mm above the soil surface between 30° and 35°C and was limited at temperatures exceeding 38°C with a relative humidity less than 62%. By contrast, the green weaver ant *Oecophylla smaragdina*, did not adjust its activity in response to changing air temperatures experienced in the months March to May. It did, however, appear to respond to light, being more active at night than during daylight over the study period. It is unlikely that weaver ants in their preferred habitat would ever experience temperatures high enough to cease activity.

Introduction

Ants often follow distinct daily cycles of activity, and operate within limits of temperature and humidity (Hölldobler & Wilson 1990). They tend to be strongly thermophilic, with few species foraging at all below 10°C (Hölldobler & Wilson 1990). Some species can tolerate extremely high temperatures: for example, the central Australian ant *Melophorus bagoti* remains active during the hottest period of a summer day when ambient temperature exceeds 50°C (Christian & Morton 1992). Many species adjust their foraging activity in response to several factors including ambient and surface temperatures. In tropical habitats, daily and seasonal changes in foraging activities of ants are related to both temperature (Torres 1984) and moisture (Levings 1983). This study uses field observations to assess the effects of ambient and surface temperatures, and relative humidity, on foraging activity in two species of tropical ants, *Iridomyrmex sanguineus* and *Oecophylla smaragdina*.

Materials and methods

The northern meat ant, *Iridomyrmex sanguineus* (Formicidae: Dolichoderinae), is a relatively large (length 6-8 mm), dominant, diurnal ant species (Greenslade

1976; Andersen 1992), very common in open vegetation in tropical Australia. Meat ants generally live in large colonies in underground nests (Barker & Greenslade 1982), with each nest having one to many entrance holes, each of which leads to a separate system of galleries and chambers (Greenslade 1979). A nest may be occupied by the same population for many years (Greenslade 1975).

The green weaver ant, *Oecophylla smaragdina* (Formicidae: Formicinae), is common throughout tropical Australia and South East Asia. It typically lives in large colonies and constructs nests by weaving the leaves of trees, which are bound by silk produced by the larvae. Green ants are one of the most successful ant species due to their ability to form large colonies and their aggressive and territorial behaviour. A colony may dominate several trees at one time and populations of half a million often occur (Hölldobler & Wilson 1990).

The present study took place near Darwin (12°26' S, 130°55' E) during March-May 1993, the transition period between wet and dry season, when conditions are often overcast with irregular heavy rain storms. The air temperature ranges from about 22° to 35°C, and relative humidity from about 35 to 98%. The meat ant nest was located on the grounds of the CSIRO laboratories Berrimah, 10 km north east of Darwin. The nest was in bare red earth and had 11 entrances, roughly in a line with a maximum separation of 23 m. Only one hole, centrally located, was selected for monitoring. The green ant nest was located in Nightcliff, 10 km north of Darwin. The monitored nest was one of eight located in a lemon tree, and was approximately 2 m above ground level on the perimeter of the tree. It had three openings but only the main entrance hole was monitored.

Activity in both species was measured by counting the number of ants entering and leaving one entrance over five minute periods. Entry/ exit counts were combined to give a measure of activity. For *I. sanguineus* the following variables were measured at each count: air temperature at 2 m (Ta), ground surface temperature (Tg), temperature at 3 mm above ground ("ant height") (Tah), nest temperature at 20 cm below surface (Tn), relative humidity at 2 m (Rh). Tg and Tah readings were taken approximately 1 m from the monitored hole. For *O. smaragdina*, only air temperature (at 2 m), nest temperature and relative humidity at 2 m were measured. Temperatures were measured with thermocouples, the nest probe being left in the ground for the entire study, and relative humidity was measured with a sling psychrometer.

To determine which environmental variable most affects the activity of *I. sanguineus*, all subsets regressions of the variables against total activity were carried out, using the adjusted r^2 as the selection factor. A paired t-test was used to test the null hypothesis that the nest temperature of *O. smaragdina* was similar to ambient temperature.

Results

Iridomyrmex sanguineus

The range of air and nest temperatures were much narrower than soil surface or ant height temperatures (Fig. 1). The model of activity with the variables Rh, Tah and Tah^2 had the highest adjusted r^2 (Table 1) and demonstrates that *I. sanguineus* prefers high humidity and medium temperatures (Fig. 2). Activity was also significantly related to ground temperature ($r^2 = 0.5181$, $p = 0.0000$) and air temperature ($r^2 = 0.3297$, $p = 0.0000$). Activity was lowest at low air temperatures, and at high air temperatures with low humidity and generally, minimum activity occured at the extreme temperatures in the ranges.

TABLE 1 *Summary of the best model describing activity of* Iridomyrmex sanguineus *over five minute periods*

Variable	Adjusted r^2	*P*
Rh	0.2323	0.0004
Rh - Rh^2	0.3939	0.0000
Tah	0.2479	0.0003
Tah - Tah^2	0.4304	0.0000
Rh + Tah - Tah^2	0.5272	0.0000

At the cooler temperatures, the ants adopted a crouched position, moved very slowly and stayed in close proximity to the nest. Some remained stationary for short periods of time. At higher temperatures their bodies were raised from the ground and they moved very quickly around and away from the nest.

O. smaragdina

The activity of *O. smaragdina* was unrelated to air temperature ($r^2 = 0.0392$; Fig. 3a) and relative humidity (adjusted $r^2 = 0.0270$). Time of day however, was a significant factor with an r^2 of 0.5488 (Fig. 3b). Maximum activity occurred during the dark hours (before 06:00 and after 18:00) and showed a 50% decrease during the daylight hours (after 06:00). There was no significant difference between mean air temperature and mean nest temperature ($t = 0.47$, $d.f. = 59$, $P > 0.05$).

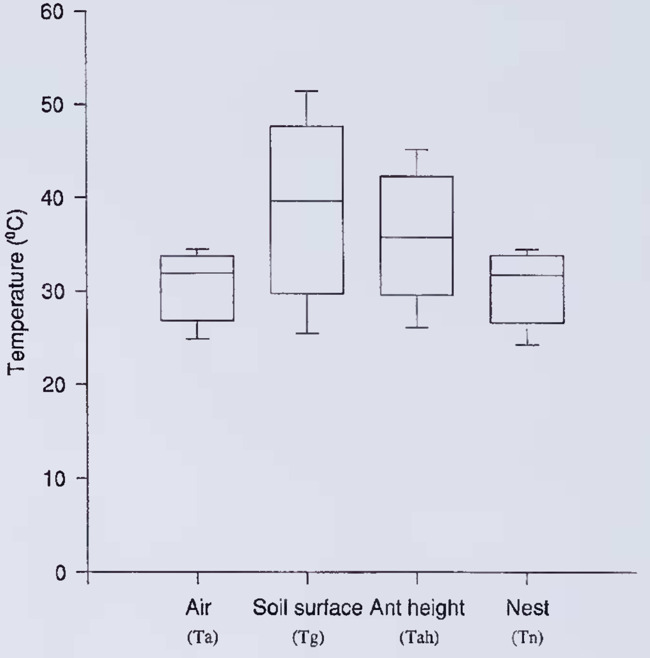

FIGURE 1 *Range of the temperature, means and standard errors at different locations. The boxes indicate the range between the 25th and 75th percentiles of the data; the lines mark the 50th percentiles, and capped bars indicate the 10th and 90th percentile points.*

Discussion

The results suggest that *I. sanguineus* activity is strongly affected by environmental temperature and relative humidity. The optimum foraging ant height temperature was around 35°C. The high temperatures occurred mainly after 11:30 and low temperatures occurred before 07:00 hours.

By contrast, *O. smaragdina* was not strongly affected by air temperature, at least within the range of 24° to 37°C, or relative humidity. Because these ants spend the majority, if not all, of their time in trees, they would be well shaded from direct and reflected solar radiation and would not experience the high temperatures occurring at ground level. Also, the thermal conductance of vegetation is lower than that of bare ground so the risk of desiccation induced by activity at high temperatures would be considerably reduced. The highest air temperature recorded was 37.5°C, which is above average, but the activity of green ants at this temperature was not significantly different than at some lower temperatures. The highest air temperature ever recorded in Darwin was 38.9°C in October 1991

(Bureau of Meteorology, Darwin, pers. comm.) so it seems unlikely that green ants would ever experience air temperatures sufficiently high in the Darwin region to prevent their activity. Greenslade (1972) found that this species is well adapted to tropical environments and is tolerant of variations in both temperature and humidity.

Ground temperature and temperature at ant height for *I. sanguineus* varied considerably more than air and nest temperature (Fig. 1). Both fluctuated readily with slight changes in wind speed and cloud cover. The ants were active over a large range of environmental temperatures but for a given temperature, activity was generally greater at high humidity when the risk of desiccation would be considerably reduced. It is significant that the lowest ant count of only one over a five minute period occurred at the highest ground temperature of 54.2°C when relative humidity was only 45%. Nest temperature by contrast, showed very little variation with a mean of 33.6°C, ranging from 26° to 36°C. It rarely fell below Ta, and then only slightly. Ground-dwelling insects intercept direct and reflected solar radiation as well as infrared radiation, conductive and convective heat from the ground. Therefore, they are particularly prone to desiccation (Withers 1990). When ambient temperatures are high it is imperative that they have some means of avoiding overheating and, for meat ants, a relatively cool nest environment provides a thermal refuge.

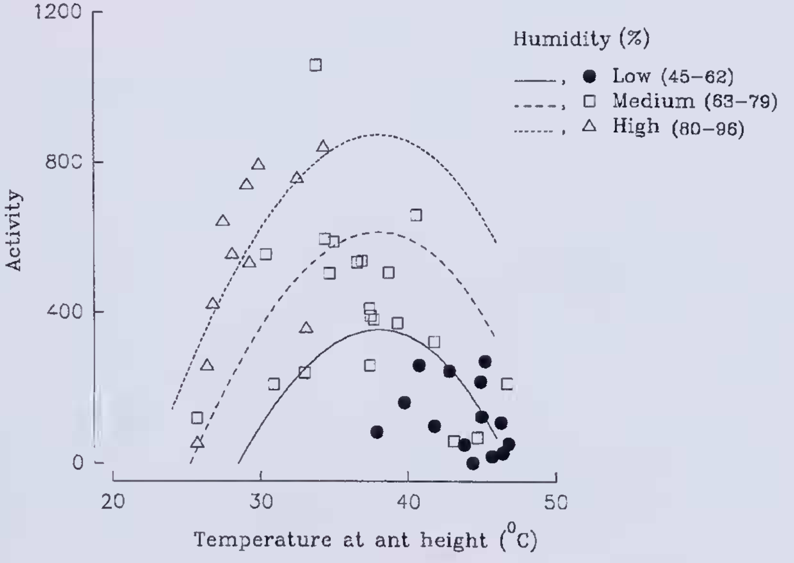

FIGURE 2 *Actual and fitted values of the activity of* ***I. sanguineus*** *over five minute periods in relation to temperature 3 mm above the soil surface (Tah) and relative humidity (Rh). The equation for the model is,* $Activity = 14.6Rh + 314Tah - 4.2Tah^2 - 6350$.

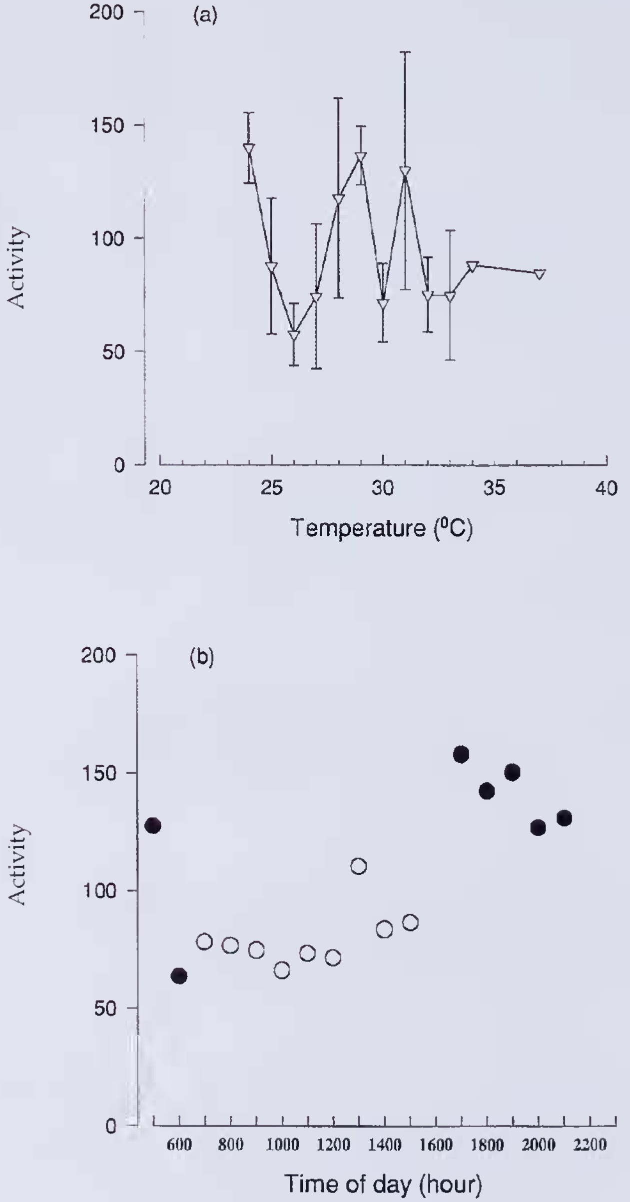

FIGURE 3 *Mean activity of* ***O. smaragdina*** *over five minute periods at (a) air temperature and (b) time of day (open circles = day; closed circles = night).*

It is possible that the energy available, if any, at low ambient and surface temperatures is too low for effective foraging. The low body posture adopted by *I. sanguineus* would maximise heat gain from the boundary layer of the ground surface. The elevated posture adopted at high ground temperatures would raise the ant's body into the cooler part of the thermal boundary layer and increase convective heat loss (Withers 1990). *Melophorus bagoti* spends up to 50% of the foraging time during midday in the refuge of sparse vegetation, and, despite soil surface temperatures exceeding 70°C, there is never a cessation of activity (Christian & Morton 1992). It is possible that *I. sanguineus* also uses this strategy for thermal respite. The fact that no other ant species were observed around the nest site and that meat ants are relatively large and aggressive, suggests that their foraging times are not affected by interspecific competition.

The nest temperature of *O. smaragdina* fluctuated with air temperature so it would not provide a thermal refuge as it does for *I. sanguineus*. When the sun was shining directly on the nest of *O. smaragdina*, the majority of ants spent most of their time in the shade on the underside of the nest, while at other times, particularly in the early morning, they moved over the entire nest (S. Walsh pers.obs.). No thermoregulatory behaviour in response to thermal extremes was observed. The lowest temperature recorded was 24.8°C and it was at this temperature that the highest activity occurred. This reading was taken at night. Activity appears to be limited by light, peaking at and after sunset and before sunrise. Activity decreased by approximately 50% during the daylight hours. It may have been useful to take more readings during the night to determine if this trend is consistent as not all nests or colonies may exhibit nocturnal behaviour.

This study revealed that *I. sanguineus* and *O. smaragdina* respond quite differently to changes in environmental temperature. The activity of the meat ant was limited by environmental temperature extremes and low relative humidity, while the green ant was tolerant of changes in ambient temperature, responding more to light. Further observations on other nests of *I. sanguineus* and *O. smaragdina* , and at other times of the year, are required to determine the generality of these findings.

Acknowledgements

I thank L. Knight and S. Walsh for carrying out the field work on *O. smaragdina*. I also thank W. M. Lonsdale and A. N. Andersen for guidance and helpful comments on a draft of the manuscript.

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PLATE 4 *The northern meat ant,* ***Iridomyrmex sanguineus*** (B. McKaige)